COMPARATIVE EFFECT OF B777 AND B747 TRAFFICKING ON ELASTIC LAYER MODULI OF NAPTF FLEXIBLE PAVEMENTS

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PRESENTED FOR THE
2004 FAA WORLDWIDE AIRPORT TECHNOLOGY TRANSFER CONFERENCE
Atlantic City, New Jersey, USA

April 2004

ABSTRACT

The elastic modulus (resilient modulus) is a fundamental material property required for characterization of pavement layers for use in mechanistic pavement analysis and design. The use of Non-Destructive Test (NDT)-based backcalculation techniques to determine layer moduli is a cost-effective and widely used method for the structural evaluation of an existing pavement. The changes in pavement layer moduli with time and traffic can be used to assess the development of distresses in a pavement. This paper illustrates the use of backcalculated Asphalt Concrete (AC) and subgrade moduli as condition indicators of flexible airport pavements subjected to trafficking. The NDT data acquired at the National Airport Pavement Test Facility (NAPTF) were used. The NAPTF pavements were subjected to B777 trafficking in one lane and B747 trafficking on the other lane using a test machine. The Falling Weight Deflectometer (FWD) tests were conducted prior to trafficking. The Heavy Weight Deflectometer (HWD) tests were conducted on the trafficked lanes as well as on the untrafficked centerline of flexible sections as trafficking progressed. From the 9-kip FWD test results, AC and subgrade moduli were backcalculated using the FAABACKCAL software and ILLI-PAVE algorithms and the results were compared. The ILLI-PAVE algorithms were validated for the NAPTF sections. The backcalculated layer moduli from 36-kip HWD test results were used to compare the severity of B777 and B747 trafficking on the NAPTF flexible sections and in assessing the degree of distress.

INTRODUCTION

The introduction of New Generation Aircraft (NGA) such as the Boeing 777 (B777) in 1995 necessitated a fundamental need to develop new pavement design procedures based on sound theoretical principles and with rational models verified from full-scale test data. A joint funding provided by the FAA and the Boeing Company under a Cooperative Research and Development Agreement laid plans for the construction of the National Airport Pavement Test Facility (NAPTF). The NAPTF is located at the Federal Aviation Administration (FAA) William J. Hughes Technical Center, Atlantic City International Airport, New Jersey. The facility was dedicated on April, 1999 and the first series of tests were conducted between September 1999 and July 2001. The test pavement area is 900 feet long and 60 feet wide. The original construction included nine test sections (six flexible and three rigid) built on three different subgrade materials: low-strength (target CBR of 4), medium-strength (target CBR of 8), and high-strength (target CBR of 20). The naturally-occurring sandy-soil material at the NAPTF site underlies each subgrade layer. Two different flexible base sections are used: conventional (granular) and stabilized (asphalt concrete).

The NAPTF pavement testing was conducted in two phases: response test program and traffic test program. This study focuses on the results from the NAPTF traffic test program. The objectives of the NAPTF traffic test program were to explore gear configuration/load and wander effects on pavement responses (stresses, strains, and deflections) by monitoring pavement responses and performance (rutting and cracking) as a function of number of load repetitions (N). Two gear configurations, a six-wheel dual-tridem landing gear (B777) in one lane and a four-wheel dual-tandem landing gear (B747) in the other lane were tested simultaneously using the National Airport Pavement Test Machine (NAPTM). Transverse surface profile (TSP) measurements as well as straightedge rut depth measurements were made throughout the traffic testing. Prior to the commencement of NAPTF traffic test program, Falling Weight Deflectometer (FWD) tests were conducted to document the uniformity of pavement and subgrade construction. Heavy Weight Deflectometer (HWD) tests were conducted at different times to monitor the effect of time and traffic on the structural condition of the pavement.

The elastic layer moduli backcalculated from FWD/HWD test results are good indicators of pavement layer condition [1]. For example, reduction in asphalt concrete (AC) layer modulus is related to the development of cracking and stripping in the AC layer. By comparing the backcalculated layer moduli of an existing pavement with that of an intact pavement, the condition or degree of distress can be assessed. Also, the elastic pavement layer moduli are required inputs for the a priori mechanistic design of a flexible pavement. The backcalculation approach is particularly appealing for characterizing subgrade soils which display large variability in subgrade modulus (as large as 35-50% over few miles of a pavement) [2]. In this study, the AC moduli and subgrade moduli were backcalculated from FWD/HWD results and the relative effect of B777 and B747 trafficking on the elastic moduli were compared. The seasonal variation in AC modulus and subgrade modulus were also characterized.

Based on extensive repeated laboratory testing data at the University of Illinois, Thompson and Robnett [3] indicated that the “breakpoint” resilient modulus (E_{Ri}), typically associated with a repeated deviator stress of about 6 psi, is a good indicator of the subgrade soil’s resilient modulus. The Asphalt Institute’s Thickness Design Manual MS-1 [4] recommends E_{Ri} (subgrade modulus at a deviator stress of 6 psi) as the subgrade modulus input for Elastic Layer Program (ELP) analysis.

The FAA’s Layered Elastic Analysis (LEA) – based backcalculation software FAABACKCAL and the finite-element based ILLI-PAVE algorithms were used in this study. The most recent version of FAABACKCAL is called BAKFAA and is available for download on the FAA Airport Pavement Technology web site: http://www.airporttech.tc.faa.gov.

NAPTF BACKGROUND

Pavement Sections. Each NAPTF test section is identified using a three-character code, where the first character indicates the subgrade strength (L for low, M for medium, and H for high), the second character indicates the test pavement type (F for flexible and R for rigid), and third character signifies whether the base material is conventional (C) or stabilized (S). Thus, the test section MFC refers to a conventional-base flexible pavement built over a medium strength subgrade, whereas test section LFS refers to a stabilized-base flexible pavement built over a low-strength subgrade. Cross-sectional views of the “as-built” NAPTF flexible test items are shown in Figure 1.

Traffic Testing. A six-wheel dual-tridem gear configuration (B777) with 54-inch dual spacing and 57-inch tandem spacing was loaded on the North wheel track (LANE 2) while the South side (LANE 5) was loaded with a four-wheel dual-tandem gear configuration (B747) having 44-inch dual spacing and 58-inch tandem spacing. The wheel loads were set to 45,000 lbs and the tire pressure (cold) was 188 psi. In the LFC and LFS test sections, the wheel loads were increased from 45,000 lbs to 65,000 lbs after 20,000 initial load repetitions. The traffic speed was 5 mph throughout the traffic test program.

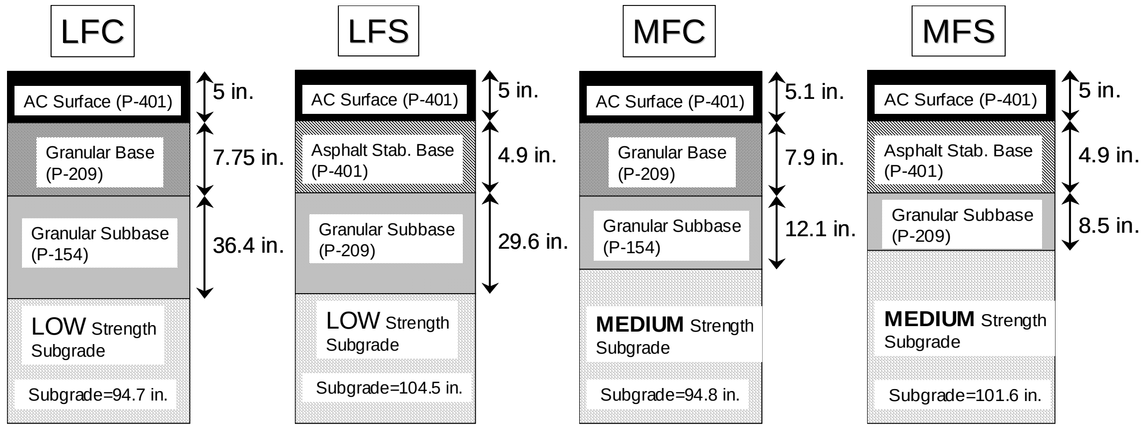

Figure 1. Cross-Sectional Views of “As-Built” NAPTF Flexible Test Sections

Failure Criterion. The NAPTF “failure” criterion was the one established in the US COE MWHGL Tests [5]. “Failure” is defined as the presence of at least 1 inch surface upheaval adjacent to the traffic lane. This is considered to reflect a *structural* failure in the subgrade.

In the definition of 1-inch surface upheaval “failure” criterion, there is no limit on the maximum rut depth. Thus, a surface upheaval of 1 inch may be accompanied by a 0.5-inch rut depth or rut depths in excess of 2 to 3 inches with no limit on the maximum allowable rut depth. However, according to the Unified Facilities Criteria (UFC) [6], a rut depth in excess of 1 inch is considered as “High” severity rutting and it constitutes a significant *functional* failure requiring major maintenance activities. Except for the high-strength (HFC and HFS) test sections, trafficking at NAPTF continued until the individual pavement test sections were considered as “failed”.

NONDESTRUCTIVE TESTS

FWD/HWD Test Details. For FWD testing, the FWD KUAB Model 150 with a segmented 12-inch loading plate and a pulse width of 27-30 msec was used. For HWD testing, the FAA HWD KUAB Model 240, also configured with a 12-inch loading plate and a 27-30 msec pulse width, was used. In particular, tests conducted on 06/14/1999 used the FWD KUAB equipment while those conducted on or after 01/11/2000 used the FAA HWD equipment.

The deflections were measured with seven seismometers spaced at 12-inch intervals (D0 to D6). The FWD tests were performed at nominal force amplitudes of 9-Kip, 13.5-Kip, 18.5-Kip, and 25.9-Kip. Tests were conducted over the following locations: 25 ft North of centerline (LANE 1), 15 ft North of centerline (LANE 2), 5 ft North of centerline (LANE 3), 5 ft South of centerline (LANE 4), 15 ft South of centerline (LANE 5) and 25 ft South of centerline (LANE 6). Centerline (C/L) tests were also conducted.

The HWD tests were performed at nominal force amplitudes of 12-Kip, 24-Kip, and 36-Kip. These tests were performed on the centerline (C/L), LANE 2 (B777 traffic lane) and LANE 5 (B747 traffic lane). The FWD/HWD test sequences were repeated at 10-foot intervals along the test lanes. The location and orientation of FWD and HWD test lanes are illustrated in Figure 3. The FWD/HWD test results can be downloaded from the FAA Airport Technology Branch website.

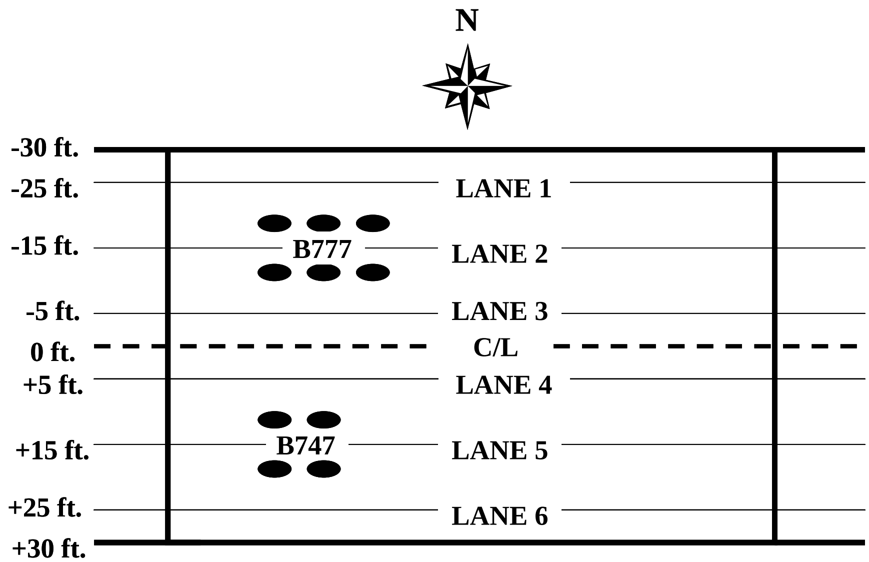

Figure 2. FWD (LANE 1, 2, 3, 4, 5, and 6) and HWD (LANE 2, 5 and C/L) Test Lanes

Pavement Temperature. The temperature of the AC layer at the time of FWD testing has a significant influence on the surface deflections. During the construction of NAPTF facility, static temperature sensors were installed at different depths along the test sections to record the pavement temperatures at different times of the day. All the FWD tests were conducted on June 14, 1999. The average daily pavement temperature on June 14, 1999 was 70.1 ^{0}F. The HWD tests were conducted between January 11, 2000 and June 6, 2001. The seasonal variation of average daily pavement temperatures computed per depth during the traffic test program is displayed in Figure 3 for NAPTF test sections. The Figure indicates that the temperatures in the AC layer show no significant variation with respect to depth (a “limited depth effect”). It should be noted that the NAPTF is an indoor testing facility.

BACKCALCULATION ALGORITHMS

In this study, only the 9-kip FWD test results and 36-kip HWD test results are considered. The main backcalculation software used in this study was the FAABACKCAL, a LEA-based backcalculation program. The backcalculated moduli results obtained from 9-kip FWD test data using the FAABACKCAL were compared with those obtained using WESDEF and the ILLI-PAVE based algorithms. Previous research studies conducted at the University of Illinois indicate that the ILLI-PAVE based backcalculation algorithms tend to produce more realistic results as ILLI-PAVE incorporates stress-sensitive material models. In studying the NAPTF Response Test results, Gomez-Ramirez and Thompson [7] have showed the presence of material non-linearity at NAPTF. Garg and Marsey [8] have similarly observed the stress-dependent nature of underlying layers at NAPTF.

However, the ILLI-PAVE algorithms were developed only for the 9-kip FWD loading. Therefore, they were not applicable for the 36-kip HWD data. As the NAPTF test sections were constructed to equally exacting quality standards on each controlled subgrade, the as-constructed depths of pavement layers and subgrades were used in the backcalculation process.

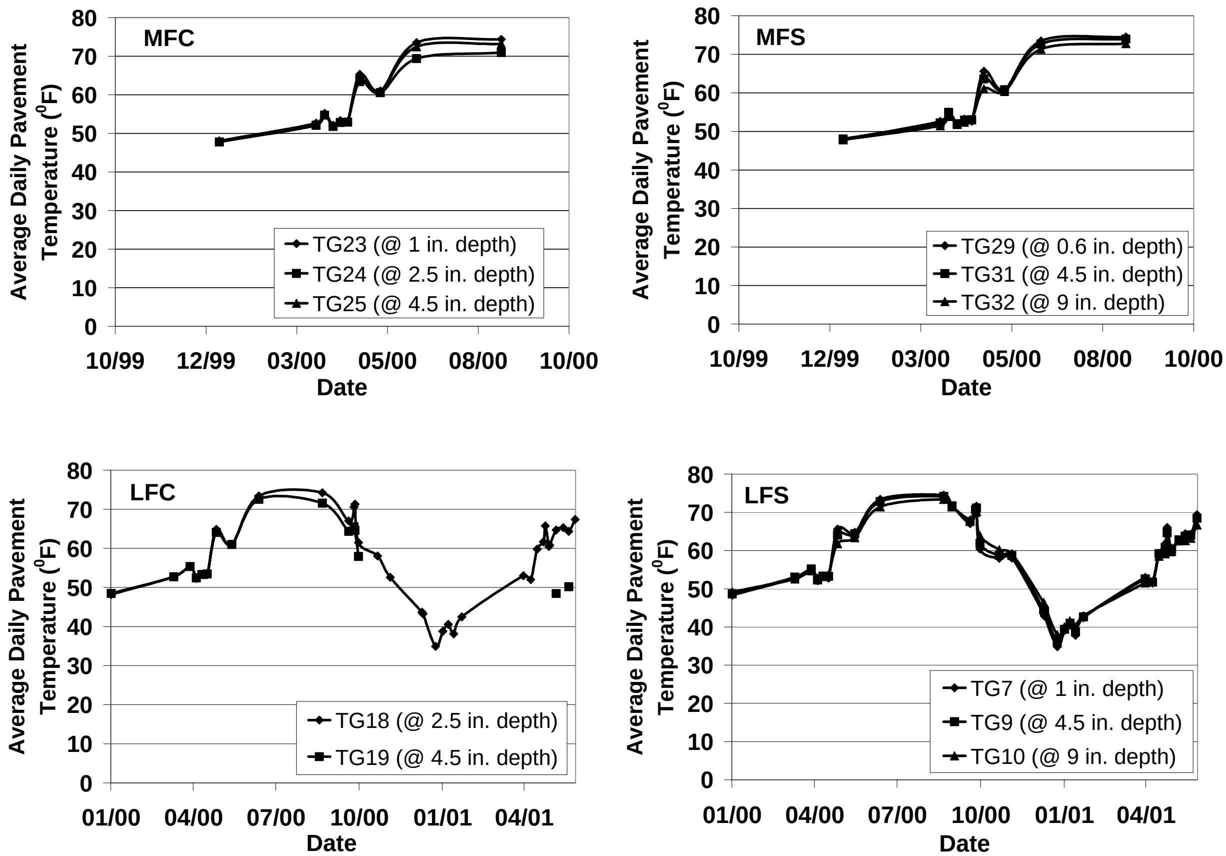

Figure 3. Average Daily Pavement Temperature Variation During Traffic Testing. TG # refers to the Temperature Gage installed at specific depth within the AC layer in a given test section.

ILLI-PAVE ALGORITHMS. The ILLI-PAVE pavement finite element program developed at the University of Illinois, Urbana-Champaign [9] is the most versatile, user-friendly, widely used (in the USA) finite element flexible pavement structural model [10]. It models the pavement as a 2D axisymmetric solid of revolution and employs nonlinear stress-dependent models and failure criteria for granular materials and fine-grained soils. Using ILLI-PAVE databases, Thompson [11] developed direct plot procedures and algorithms for backcalculating pavement layer and subgrade moduli from 9-kip FWD test results.

For a conventional AC pavement (AC + granular base), the algorithms are:

Subgrade Modulus

$$E_{Ri} = 24.1 - 5.08 * D3 + 0.28 * D3^2$$

$$R^2 = 0.97 \qquad SEE = 0.76$$

AC Modulus

$$LOG\ E_{AC} = 1.48 + 1.76 * LOG\left(\frac{AREA}{D0}\right) + 0.26 * \left(\frac{AREA}{T_{AC}}\right)$$

$$R^2 = 0.95 \qquad SEE = 0.110$$

Where

E_{AC} = AC modulus (ksi)

E_{Ri} = Subgrade soil resilient modulus at a repeated deviator stress of 6.2 psi (ksi)

D0 = surface deflection @ 0 inches from center of loading plate (mils)

D3 = surface deflection @ 36 inches from center of loading plate (mils)

T_{AC} = thickness of the AC layer (inches) (5 in. for LFC and MFC; 10 in. for LFS and MFS test sections)

AREA = a deflection basin parameter (inches)

[AREA (in.) = 6(1 + 2(D1/D0) + 2(D2/D0) + (D3/D0))]

It is noted that the granular base thicknesses used in the development of these algorithms ranged between 4 to 24 inches. However, the granular layer (base+subbase) thicknesses of LFC and LFS sections at the NAPTF exceed 24 inches. To determine the validity of these algorithms for the NAPTF test sections, ILLI-PAVE analyses were conducted to study the influence of increased base thicknesses on the parameters included in the algorithms. The variations in ($AREA/T_{AC}$) term and ($AREA/D_0$) term with changes in base thicknesses were studied and were found to be insignificant. It was concluded that the original ILLI-PAVE algorithms are adequate for analyzing the NAPTF flexible test sections.

WESDEF. The WESDEF backcalculation program developed by Van Cauwelaert et al [12] uses the WESLEA multi-layer elastic analysis program. It utilizes an iterative procedure to obtain a set of moduli that, when used in linear-elastic calculations, will produce deflections similar to the measured values. A maximum of twenty loads and five pavement layers with varying interface conditions may be entered in WESDEF. The fifth layer is semi-infinite and can be made stiff based on the choice of elastic modulus. The program has the ability to backcalculate moduli values using deflections with depth, such as those obtained using MDDs, as well as with surface deflections. The material type, entered for each layer in the pavement structure, is used to establish the default initial modulus, minimum and maximum moduli, the Poisson’s' ratio, and the interface slip values. The modulus for the stiff layer was set to 1,000,000 psi with a Poisson’s ratio of 0.50. A Visual Basic program was written to enable WESDEF to handle batch computations.

FAABACKCAL. FAABACKCAL was developed under the sponsorship of the FAA Airport Technology Branch and is based on the LEAF layered elastic computation program. In this program, the pavement layer moduli and subgrade moduli are adjusted to minimize the root mean square (rms) of the differences between FWD/HWD sensor measurements and the LEAF-computed deflection basin for a specified pavement structure. A standard multidimensional simplex optimization routine is then used to adjust the moduli values [13]. A stiff layer with a modulus of 1,000,000 psi and a Poisson’s ratio of 0.50 was used in backcalculation. Based on the as-constructed conditions, the stiff layer was set at 10 ft. for the medium-strength test sections and at 12 ft. for the low-strength sections. The most recent version of the FAA backcalculation software is called BAKFAA.

BACKCALCULATION RESULTS FOR 9-KIP FWD DEFLECTIONS

The AC moduli backcalculation results are summarized in Table 1. The AC moduli values backcalculated using WESDEF match very well with the results from FAABACKCAL for all sections. The results from WESDEF and FAABACKCAL match well with the ILLI-PAVE results for conventional (MFC and LFC) sections whereas in the case of stabilized (MFS and LFS) test sections, the ILLI-PAVE based algorithms produce higher AC moduli values. It is noted that the P-401 AC mix was used as the surface layer for all the flexible test sections and should show a fairly constant AC modulus for all the test sections. The FAABACKCAL produced the most consistent AC moduli.

The resilient moduli of low-strength subgrade sections (LFC and LFS) are lower than those of medium-strength subgrade sections (MFC and MFS). This is consistent with the subgrade CBR values (CBR 4 for low-strength and CBR 8 for medium-strength subgrades). The resilient moduli values from all three methods match quite well. For medium strength test sections, FAABACKCAL and WESDEF produce slightly higher results than those produced by ILLI-PAVE algorithms whereas the opposite is true for the low-strength test sections. The laboratory resilient modulus tests performed in accordance with SHRP P-46 procedure indicate that the moduli for low-strength subgrade and medium-strength subgrade are 7,500 psi and 12,500 psi at a confining stress of 6 psi and a deviator stress of 2 psi. At a deviator stress of 6 psi, the resilient moduli (E_{Ri}) values are 3,000 psi for low-strength subgrade and 9,000 psi for medium-strength subgrade. These results are based on laboratory testing of Shelby tube samples obtained from test pits before the test sections were opened to traffic.

BACKCALCULATION RESULTS FOR 36-KIP HWD DEFLECTIONS

Variation in AC Modulus with Temperature. The AC layer is significantly influenced by the temperature and the subgrade moduli may vary with the time of the year. The HWD tests were conducted on the trafficked lanes as well as on the untrafficked Centerline (C/L) of the test pavement. Therefore, the C/L HWD data can be used to characterize the seasonal variation in backcalculated AC and subgrade modulus. Both FAABACKCAL and ILLI-PAVE algorithms were used for backcalculating the moduli. To use the ILLI-PAVE algorithms, the 12-kip HWD deflections were normalized to 9-kip loading as the deflections were fairly linear in this range.

After combining the data for all four sections, a linear regression was performed to develop an overall E_{AC} – Temperature relation. The E_{AC} – T relations obtained using FAABACKAL and ILLI-PAVE algorithms are shown in Figure 4 along with the laboratory measured AC modulus at 77 ^{0}F. The laboratory testing was conducted at the University of Illinois (UofI) on P-401 AC cores obtained from the NAPTF test sections prior to trafficking. Also shown for comparison is the E_{AC} – Temperature relation proposed by Witczak [14]. The following E_{AC} – Temperature relation was proposed by Witczak [14] and it is included in LEDFAA (a computer program for airport pavement thickness design):

$$E = 10^{(6.53658 - 0.006447T - 0.00007404T^2)}$$

where E = AC modulus (psi)

and T = AC temperature (^{0}F)

Table 1.
Summary of Backcalculated Moduli Values from 9-kip FWD Deflection Basins.

Backcalculated AC Modulus (ksi)									
Test Section	***ILLI-PAVE Algorithms***			***WESDEF***			***FAABACKCAL***		
	Mean	Std. Dev.	%COV	Mean	Std. Dev.	%COV	Mean	Std. Dev.	%COV
LFC	732	161	21.9	597	139	23.3	595	124	20.8
LFS	930	105	11.3	602	66	11.0	596	60	10.1
MFC	526	161	30.6	400	112	27.9	505	89	17.5
MFS	815	95	11.6	388	38	9.9	438	61	13.8
Backcalculated Subgrade Modulus (ksi)									
Test Section	***ILLI-PAVE Algorithms***			***WESDEF***			***FAABACKCAL***		
	Mean	Std. Dev.	%COV	Mean	Std. Dev.	%COV	Mean	Std. Dev.	%COV
LFC	8.6	0.9	10.8	6.7	0.7	10.1	6.7	0.8	12.0
LFS	7.5	1.2	15.7	6.7	0.9	13.4	6.7	0.9	14.0
MFC	11.3	0.5	4.7	12.3	0.6	4.8	12.9	0.5	3.9
MFS	12.2	0.4	3.0	14.7	3.1	20.8	14.8	1.0	6.6
AC Temperature = 70.1^{0} F									

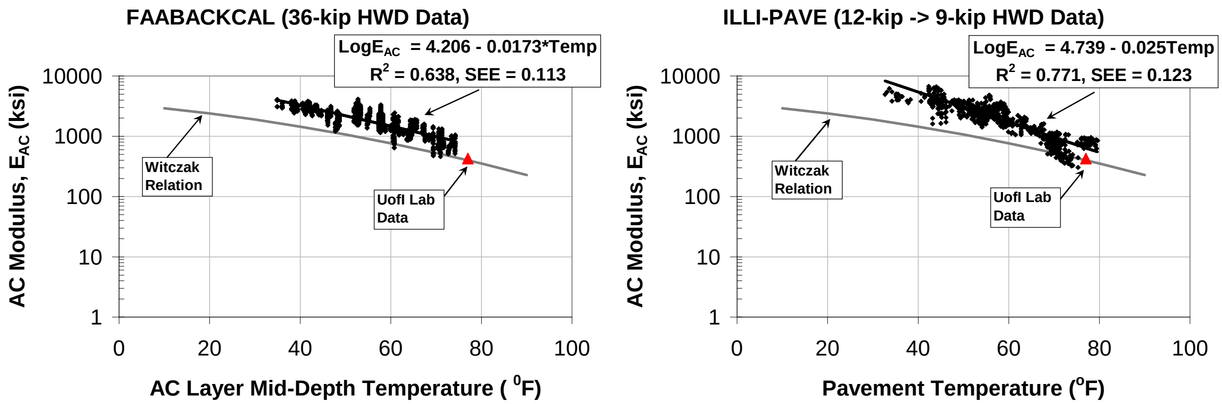

Figure 4. E_{AC} – Temperature Relations Using FAABACKCAL and ILLI-PAVE Algorithm

Seasonal Variation in Subgrade Modulus. The subgrade modulus was backcalculated from the C/L HWD data using the FAABACKCAL (denoted as E_{sub}) and ILLI-PAVE algorithm (denoted as E_{Ri}). The variation in subgrade modulus over the duration of trafficking is shown in Figure 5 for FAABACKCAL and in Figure 6 for ILLI-PAVE algorithm. It is noted that the medium-strength test sections (MFC and MFS) "failed" by August 2000, whereas the traffic testing on the low-strength test sections (LFC and LFS) continued until July 2001. Interestingly, the variation in subgrade modulus is low (Coefficient of Variations ranging from 2% to 8%) for each test date using both the methods. The untrafficked C/L subgrade moduli backcalculated using the FAABACKCAL (E_{sub}) are compared with the ILLI-PAVE algorithm (E_{Ri}) results in Figure 7.

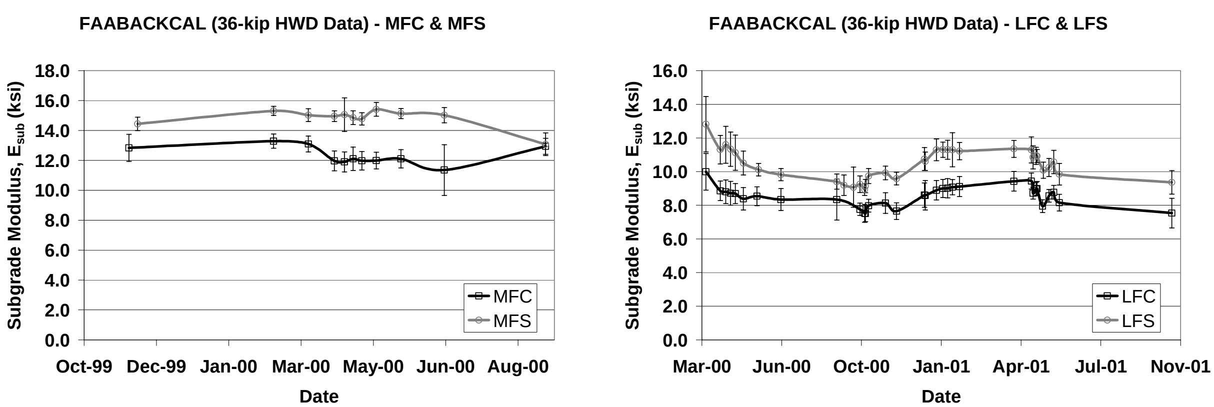

Figure 5. Variation of Backcalculated E_{Ri} with Time (FAABACKCAL)

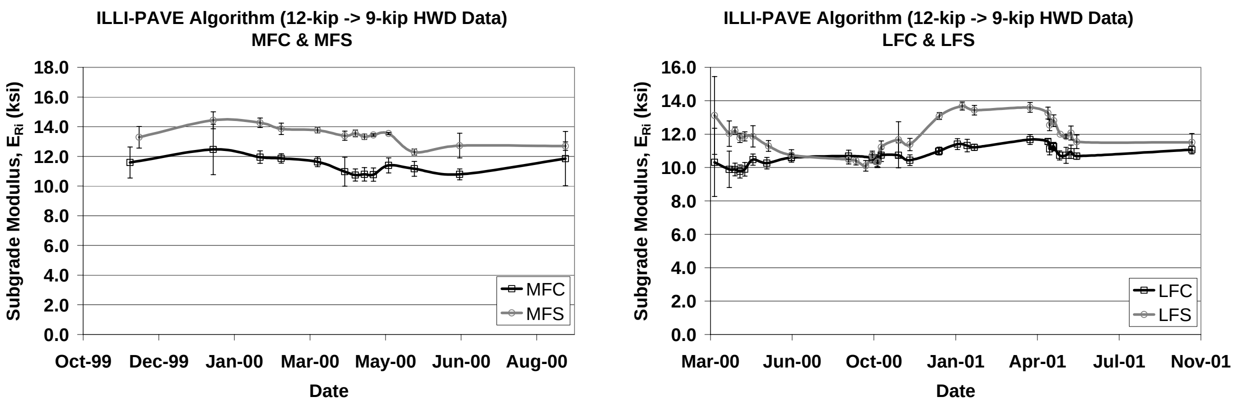

Figure 6. Variation of Backcalculated E_{Ri} with Time (ILLI-PAVE Algorithm)

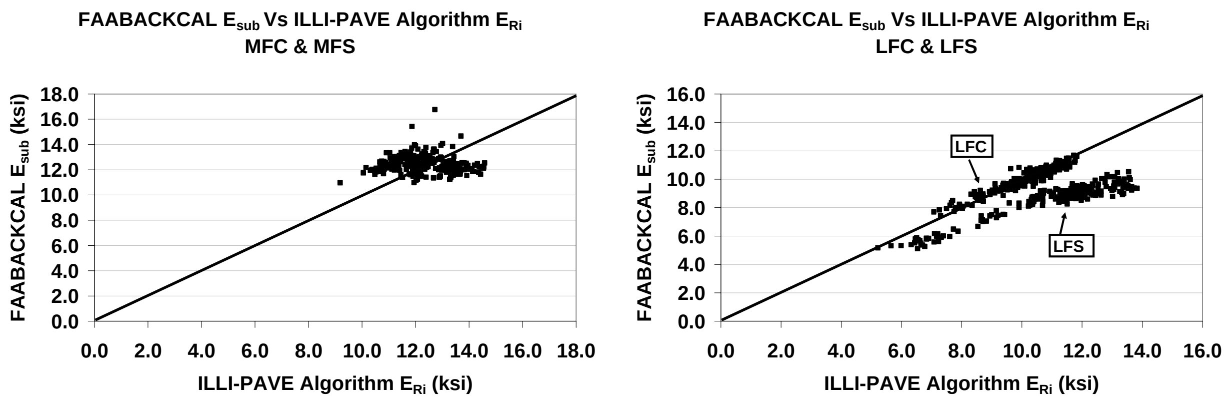

Figure 7. FAABACKCAL E_{sub} Versus ILLI-PAVE Algorithm E_{Ri}.

Variation in AC Modulus and Subgrade Modulus with Trafficking. To study the loss of stiffness resulting from trafficking, the E_{AC} and E_{sub} values were backcalculated from the 36-kip HWD data using the FAABACKCAL. Note that the 36-kip HWD testing was performed at various times during the trafficking on LANE 2 (B777 traffic lane), LANE 5 (B747 traffic lane) and the untrafficked Centerline (C/L) of the test pavement. It is reasonable to assume that the variation in moduli values in the C/L is mainly due to climatic effects. Thus, the variation in E_{AC} and E_{sub} values in the traffic lanes can be compared to the corresponding C/L values and the degree of structural distress induced by B777 trafficking and B747 trafficking can be assessed.

The change in AC moduli and subgrade moduli values with the number of load repetitions (N) is shown in Figure 8 for the MFC section. The results for the MFS section are presented in Figure 9. Along with the AC moduli values, the variation in AC layer mid-depth temperature during trafficking is also plotted. The backcalculated AC moduli values are significantly influenced by temperature.

In the MFC test section, the E_{AC} values obtained from the B747 traffic lane are consistently lower than those obtained from the B777 traffic lane indicating the relative severity effects. Note that at around 3,556 passes, the E_{AC} for the untrafficked C/L is 2,180 ksi, while it is 1,440 ksi (66% of C/L value) for the B777 traffic lane and 900 ksi (41% of C/L value) for the B747 traffic lane. In the laboratory fatigue testing of AC specimens in constant strain mode, failure has been widely defined as 50% reduction in the initial stiffness [15]. Sharp and Johnson-Clarke [16] suggest that a pavement may be considered to be failed when moduli are reduced by more than 50 percent. A longitudinal crack was observed on the B747 side around 3,556 passes. A crack on the B777 side of the pavement was observed close to 4,500 passes. Although, the pavement temperature has decreased from 54 ^{0}F (at 931 passes) to 52 ^{0}F (at 3,556 passes), the E_{AC} values, instead of showing an increase, have decreased significantly in both the traffic lanes indicating the loss of stiffness resulting from trafficking.

The NAPTF rutting study conducted by Gopalakrishnan and Thompson [17] indicated that the rut depths (based on transverse surface profiles) increased from 0.9 inches at 870 passes to 1.4 inches at 3,552 passes on the B747 side and from 0.7 inches at 870 passes to 1 inch at 3,552 passes on the B777 side. The B747 side rut depths were consistently higher than the rut depths measured on the B777 side throughout the trafficking although the differences were not significant from an engineering standpoint. The plot of E_{sub} Vs N for the MFC section shows that the E_{sub} values remain close to 13 ksi throughout the trafficking. However, the post-traffic trench study conducted on the MFC section showed that the subgrade layer contributed significantly to the rutting [18]. It is noted that the FAABACKCAL is based on the multi-layered linear elastic analysis (LEA) program LEAF which does not account for the stress-sensitivity of the unbound granular materials and cohesive subgrade soils. Finally, the backcalculated subgrade modulus itself may not be a good indicator of the rutting potential. Also, it is not known where the HWD tests were conducted in the rutted area. If the tests were conducted in the middle of the rutted areas (which were wide in extent) and not near the edge where subgrade shear occurred, a difference in backcalculated subgrade modulus may not result as a result of trafficking. In fact, a slight increase in subgrade modulus in the area tested may have occurred from compaction.

In the MFS test section, the backcalculated E_{AC} values are strongly correlated with the pavement temperature. The C/L values and the traffic lane values remain close to each other throughout the trafficking. The E_{sub} values are close to 14 ksi throughout the trafficking period.

For the LFC test section, the variations in AC moduli and subgrade moduli with N are shown in Figure 10. The results for the LFS section are presented in Figure 11. In the Figures, an arrow is shown at 20,000 passes where the wheel loading was increased from 45-kips to 65-kips. Again, the changes in E_{AC} values are strongly linked to changes in pavement temperature. The untrafficked C/L values and the trafficked lane values remain close to each other until 20,000 passes. After 20,000 passes the trafficked lane values show significant decrease compared to the C/L values. This is especially true in the LFC test section. At 19,937 passes under the 45-kip loading, the C/L E_{AC} value is 1,280 ksi while it is 650 ksi (51% of C/L value) in the B777 traffic lane and is 870 ksi (68% of C/L value) in the B747 traffic lane. After 22,000 passes under 65-kip loading, the E_{AC} values are 1,770 ksi in the C/L, 490 ksi (28% of C/L value) in the B777 traffic lane and 720 ksi (41% of C/L value) in the B747 traffic lane. The E_{sub} values are close to 8 ksi in the LFC section and 9 ksi in the LFS section throughout the trafficking period.

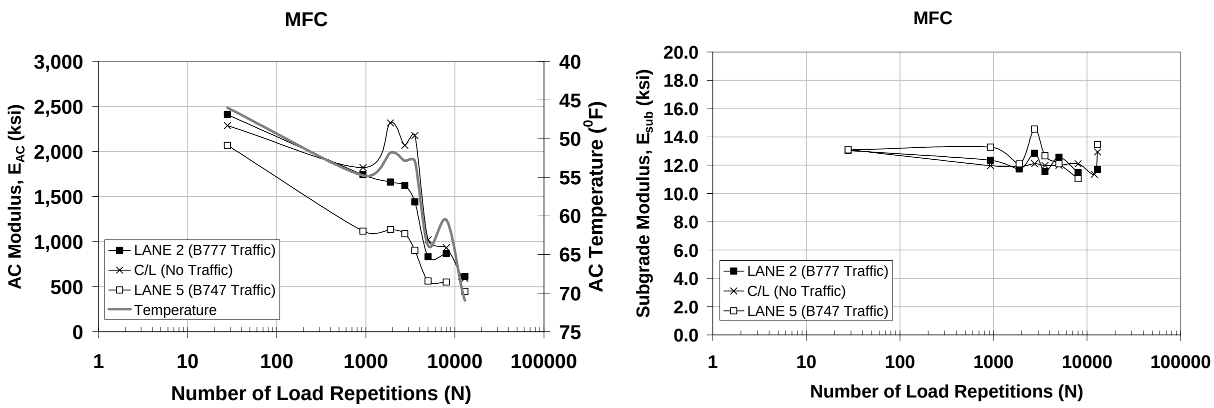

Figure 8. FAABACKCAL Backcalculated Moduli at Different Stages of Trafficking for MFC Section

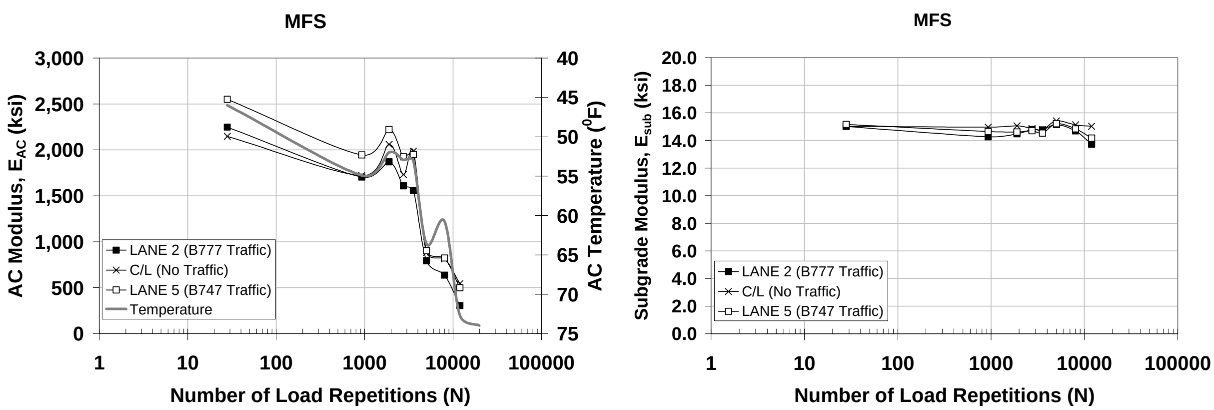

Figure 9. FAABACKCAL Backcalculated Moduli at Different Stages of Trafficking for MFS Section

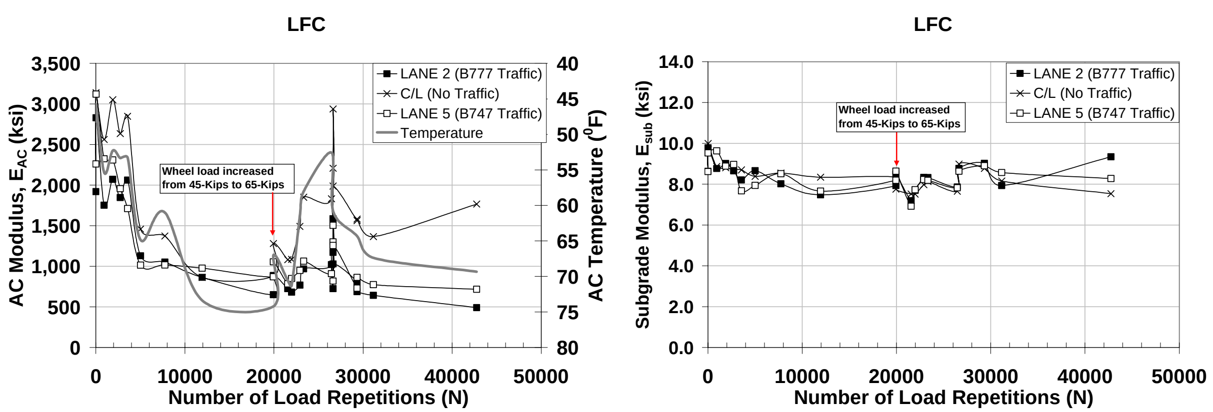

Figure 10. FAABACKCAL Backcalculated Moduli at Different Stages of Trafficking for LFC Section

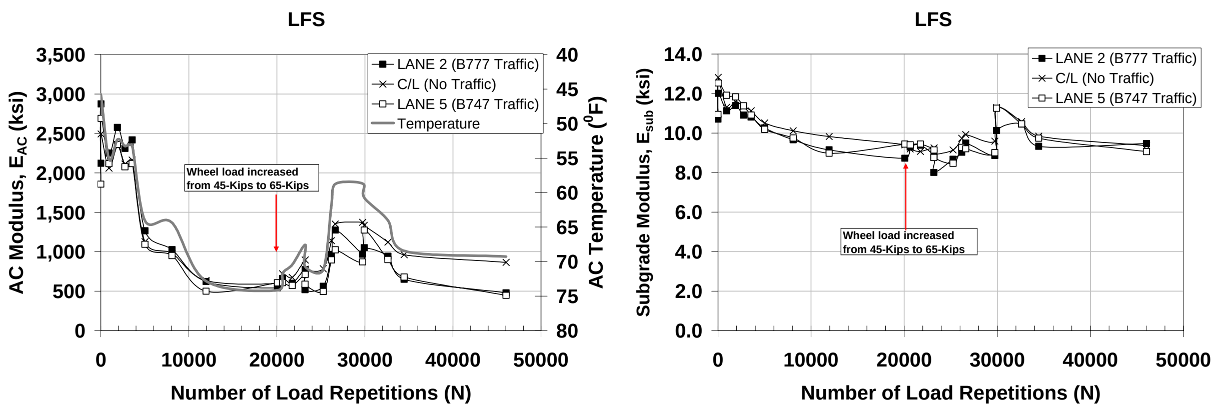

Figure 11. FAABACKCAL Backcalculated Moduli at Different Stages of Trafficking for LFS Section

SUMMARY AND CONCLUSIONS

The National Airport Pavement Test Facility (NAPTF) was constructed to generate full-scale testing data to support the investigation of the performance of airport pavements subjected to complex gear loading configurations of new generation aircraft. Nondestructive tests (NDTs) were conducted at NAPTF with both Falling Weight Deflectometer (FWD) and Heavy Weight Deflectometer (HWD). FWD/HWD deflection basins were used to backcalculate AC and subgrade moduli. The loss of stiffness resulting from trafficking was studied. Significant findings of the study are:

- The NAPTF is an indoor facility and AC layer temperatures show little/no significant variation with respect to depth (a “limited depth effect”).
- The backcalculation results from 9-kip FWD deflection basins show consistency between ILLI-PAVE algorithms, WESDEF and FAABACKCAL.
- The backcalculated subgrade moduli and AC moduli are consistent with the results from the laboratory testing.
- The seasonal variation in AC modulus and subgrade modulus were characterized using the backcalculated results. These could be used for establishing inputs to structural analysis.
- The reduction in backcalculated AC moduli as a result of trafficking was clearly observed in the MFC and LFC test sections. The E_{AC} was significantly reduced after the introduction of 65-kip wheel loading in the LFC test section.

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